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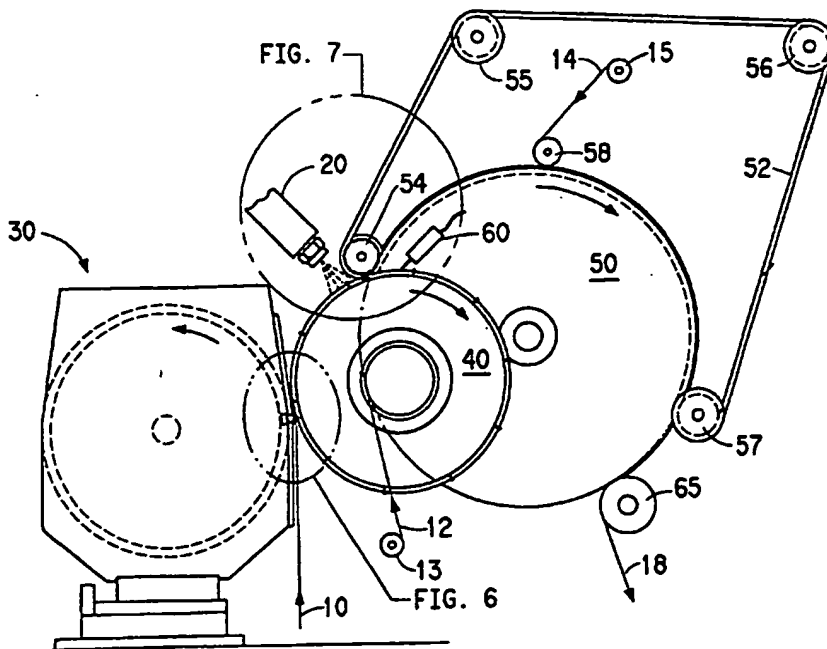
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(54) Title: PROCESS AND APPARATUS FOR MAKING COMPOSITE SHEET



(57) Abstract

A process and an apparatus for high speed manufacture of a composite sheet material includes a cylindrical-cam-driven strand-traverse guide that loops strand, preferably spandex, around pins projecting from a pair of advancing pin conveyors which then transfer the strand to the surface of a moving sheet. Elastic composite sheet material is particularly suited for use in elastic components of disposable diapers, adult incontinence articles and other garments.

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TITLE**Process and Apparatus for Making Composite Sheet****BACKGROUND OF THE INVENTION****Field of the Invention**

5 This invention relates to a process and apparatus for making a composite sheet material wherein a strand is attached transversely to a moving sheet. More particularly, the invention concerns a high speed process and apparatus in which a strand, carried by a reciprocating strand traverse guide that is driven by a cylindrical cam, is looped around pins
10 projecting from a pair of pin conveyors which then transfer the strand from the pins to the surface of the moving sheet. The invention is especially useful for high speed manufacture of elastic composite sheet material that can be attached as elastic components to disposable diapers, adult incontinence articles and other garments.

Description of the Prior Art

15 Processes and apparatus are known in which a continuous filament or strand is laid across and attached to the surface of moving sheet. For example, Estee et al, United States Patent 2,812,797, discloses an apparatus for making a laminated fabric. In the apparatus, a sheet is
20 continuously advanced between two endless belts that travel in unison and in the same direction as the sheet. One belt is located at each edge of the sheet and each belt has a series of pins projecting from its surface. A swinging frame traverses a plurality of continuous filaments back and forth across the sheet. At each reversal of the traverse, each filament from the
25 frame is looped around a corresponding pin of the belt. Adhesive is applied to the sheet and the filaments. Then, the filaments are disengaged from the pins and adhered to the sheet surface to form an assembly of filaments and sheet. A cover sheet is placed atop the assembly and passed with the filament/sheet assembly between calender rolls to produce the laminated
30 fabric. In another method, disclosed by Hirsch, U. S. Patent 2,962,080, an endless chain mechanism equipped with spaced apart pins, or a swinging lever mechanism equipped with a thread guide, traverses a thread across a sheet that is moving perpendicularly to the path of the traverse. Outside each edge of the sheet is a moving endless chain, equipped with a plurality
35 of spaced apart pins. The thread from the traversing mechanism, at one end of each traverse path, deposits the thread around a pin on the chain at one edge of the sheet and then at the other end of the traverse path deposits thread on a pin of the chain on the other edge of the sheet. Although this

method is suitable for use with non-elastic thread, the method is slow and unsuited for use with elastic thread.

Other methods for traversing filaments or strands across a moving surface to form reinforced sheets, scrims or nets also are known.

5 For example, a reciprocating conveyor is disclosed by Friedrich, U. S. Patent 4,080,232, for laying threads on the outer surface of a rotating cylinder that has barbs projecting from both edges of the cylindrical surface to restrain the threads and form an open mesh net-like structure. Kelly et al, U. S. Patent 4,600,468, also discloses a method for laying out biased arrays
10 of parallel yarns on conveyors equipped with needles to restrain the yarns and adhesively bonding the arrays together to form a bias-laid nonwoven fabric. A rotating arm is disclosed by Persson et al, U.S. Patent 5,221,390, for positioning conventional or elastic threads on "dogged elements" (e.g., pins or studs) projecting from a pair of belts located at the edges of a
15 conveyor path. Merkatoris et al, U.S. Patent 5,000,806, discloses a method and apparatus for applying elastic strand to a disposable diaper by means of canted, spindle-equipped wheels for engaging the elastic strand, moving the strand into a sinuous configuration, stretching the strand and thereafter applying the strand transversely to an advancing component of the diaper.

20 Each of the above-described methods and apparatuses are rather complex and do not attain high speeds which are desired for efficient and economical attachment of strand in a transverse direction to a moving substrate. Further, some of these methods are not suited for handling elastic strands. Accordingly, an object of this invention is to provide a process and
25 apparatus that will rapidly and economically attach elastic strand transversely to a moving sheet. Another object is to provide a garment having an elastic component made by the process and apparatus of the present invention.

Though not concerned with the problems associated with
30 attaching strand to moving sheets, various mechanisms for traversing strand across a path are known. For example, Altice et al, U.S. Patent 3,086,722, and Akers et al, U.S. Patent 3,675,863, disclose yarn traversing guides driven by rotating cylindrical cams for high speed winding of yarn packages, such as bobbins, cakes and the like.

35 SUMMARY OF THE INVENTION

The present invention provides an improved process for making a composite sheet material, in which a sheet substrate is advanced in a machine direction and a continuous strand is attached to the surface of the

sheet transversely to the machine direction (i.e., in a generally cross-machine direction). The process comprises the following combination of steps:

5 advancing a sheet substrate, a first conveyor and second conveyor in a longitudinal direction, the sheet having two lateral edges and an upper and a lower surface and each conveyor having a plurality of spaced apart pins extending therefrom in a direction generally perpendicular to the movement of the conveyor;

10 supplying a strand to a device that reciprocates the strand to and fro across a traverse path, the traverse path being generally transverse to the longitudinal direction of the advancing sheet substrate;

15 advancing the conveyors to move the pins through a semicircular path that intersects the traverse path of the reciprocating device, thereby causing the strand to repetitively loop alternately at each end of the traverse path, around a pin on the first conveyor and then on a pin of the second conveyor to form a strand array carried by the pins;

 applying an adhesive to the strand array and/or the advancing sheet substrate;

20 transferring the strand array from the pins to the upper surface of the advancing sheet substrate to form a strand-sheet assembly; optionally adhering a cover sheet atop the strand-sheet assembly; and forwarding the resultant composite sheet material to a windup or further processing.

25 The improvement of the process of the invention comprises: feeding the strand to a strand traverse guide driven by a rotating cylindrical cam, which typically traverses the strand at a rate in the range of 250 to-3,000 to-and-fro cycles per minute;

30 advancing the sheet substrate on a moving sheet-support; and restraining each edge of the strand array in position on the sheet substrate from a location after the point where the strand array is transferred from the pins to the advancing sheet substrate to a location beyond the point where the applied adhesive has become set.

35 Typically, the traverse reciprocating traverse guide has a stroke (i.e., one-half of a to-and-fro cycle) that is at least 5 centimeters long, preferably at least 10 cm. Preferably, the strand is an elastic strand, most preferably a spandex. The elastic strand is elongated in the range of 10 to 400% beyond its original relaxed length while being supplied to the strand traverse guide and/or while being restrained in the strand array.

The resultant composite sheet material when formed with non-elastic strand is reinforced in the transverse direction of the composite sheet material. Composite sheet that was formed with elastic strand is elastic in the transverse direction. Such an elasticized composite sheet material can
5 be cut into tapes or swatches of suitable dimensions and fed directly to the elastic swatch applicator of a garment-making machine to form the desired elastic component in the garment.

The invention also provides an apparatus for performing the above-described process and a garment having an elastic component made
10 with an elastic composite sheet material of the process.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood by reference to the attached drawings in which:

Fig. 1 is a side view schematic diagram of an apparatus for
15 making composite sheet material according to the invention showing relative locations of housing 30 which holds a cylindrical cam and a strand traverse guide, pin-conveyor wheel 40 and sheet support drum 50;

Fig. 2 is a partial top view of a portion of the apparatus of Fig. 1 showing strand 10 looped around the pins of 42, 42' of pin-conveyor wheels 40, 40',
20 and forming a strand array 16 on support drum 50, the array being transferred atop moving sheet 12 and held in place on the drum surface by restraining belts 52, 52';

Fig. 3 is an isometric view illustrating the operation of the portion of the equipment of Fig 1 that is located downstream of traverse
25 guide 36;

Fig. 4 is a side view of another suitable arrangement of housing 30, pin-conveyor wheel 40, sheet support drum 50 and restraining belt 52;

Fig 5 is a side view of still another arrangement of housing 30, pin-conveyor wheel 40, sheet support drum 50 and restraining belt 52 for an
30 apparatus of the invention for making composite sheet material 18 with a cover sheet 14;

Figs. 6 and 7 are each an enlarged side view of an area enclosed by dashed lines in Fig. 1;

Fig. 8 is a partial cut-away front view of housing 30 showing
35 cylindrical cam 32, strand guide 36, positioned between upper and lower traverse guide rails 34 and 35 respectively;

Fig. 9 is a front view of cylindrical cam 32 having groove 33 into which the cam follower portion of the strand guide is fitted and slides;

Fig. 10 a, b and c illustrate planar developments of three profiles of the groove 33 of cylindrical cam 32;

Fig. 11a and 11b each depict in a detailed side-view cross-section, similar to that of Fig. 6, two geometries for guide rails 34 and 35;

5 Fig. 12 is a top view detailed cross-section of cam follower 38 in groove 33 of cylindrical cam 32 and of slotted tip 37 of strand traverse guide 36;

Fig. 13 depicts another embodiment the slotted tip 37 of strand guide 36;

10 Fig. 14a and 14b are respectively a front view and a side view of pin-conveyor wheel 40;

Fig. 15a and 15b illustrate in detailed side view two embodiments of pins 42 mounted on a pin-conveyor wheel 40;

15 Fig. 16a and 16b respectively illustrate in top view two embodiments of pin-conveyor wheels 40 and 40' canted inwardly or outwardly in relation to sheet 12 to be advanced on sheet support drum 50; and

Fig. 17a, 17b, 17c, 17d and 17e each illustrate a different strand array 16 of strand 10 applied to advancing sheet 12.

20 **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

Preferred embodiments of the process and apparatus for making composite sheets in accordance with the invention will now be described in with reference to the accompanying Figures.

25 The apparatus comprises three main components; namely, a cam-driven guide housing 30, pin conveyors 40, 40' and a sheet forwarding and supporting unit 50. Housing 30 contains cylindrical cam 32 that drives strand traverse guide 36 to cause strand 10 to be looped around pins 42, 42' of a pair of pin conveyors 40, 40' to form a strand array 16. A sheet 12 is advanced on sheet support unit 50 and assembled with strand array 16 and
30 optionally with a cover sheet 14 to form composite sheet material 18, which then can be wound up or forwarded to further processing operations.

In accordance with the process of the invention, strand 10 is supplied to strand traverse guide 36 from below the guide as shown in Figs. 1 and 5, or from above the guide as shown in Fig. 4. When spandex is
35 employed as the strand to be incorporated into the composite sheet material, a simple feed path is preferred for the strand from the supply to the traverse guide with as few idler rolls as practicable. One idler roll may suffice to feed the strand from a supply package (e.g., a bobbin or a cake) to the

5 traverse guide. Such a feed path minimizes the amount of friction and tension to which the strand is subjected and permits smoother, more uniform feeding of strand to the apparatus. Typically, the spandex is supplied to the apparatus with an extension of 10 to 400% beyond the relaxed length of the spandex.

As illustrated in Figs. 6, 8, 11a, 11b and 12, strand traverse guide 36 has cam follower portion 38 that is mounted in groove 33 of rotating cylindrical cam 32. Strand guide 36 rides between upper and lower rails 34 and 35. As cylindrical cam 32 is rotated, strand traverse guide 36
10 traverses a path that is perpendicular to and intersected by the paths of pins 42, 42' carried by two spaced-apart pin conveyors. In the figures, the pin conveyors are illustrated as pin-conveyor wheels 40, 40'. Each wheel has a plurality of pins 42, or 42' projecting from its circumference. As wheels 40, 40' are rotated, strand 10 is looped by strand traverse guide 36 around each
15 pin, first on a pin of one pin-conveyor wheel and then on a pin of the other pin-conveyor wheel, to form strand array 16. For each cycle of the traverse guide to and fro, each pin-conveyor wheel is advanced by the angular distance between successive pins. Strand array 16 is then carried by the rotating pin-conveyor wheels into contact with advancing sheet 12 as the
20 sheet is fed from supply roll 13 onto and advanced by a sheet support surface, illustrated in the figures as rotating drum 50. A short distance upstream of the location where strand array 16 contacts advancing sheet 12 an adhesive, preferably a melt adhesive, is applied to the strand array and/or the sheet by spraying, dripping, or other means. In Figures 1, 5 and 7, the
25 adhesive is applied through adhesive spray applicator 20. The strand array is carried by continued rotation of the pin-conveyor wheels into one or more nips located near each edge of the strand array. The nips are formed by restraining belts 52, 52', preferably V-belts, and the circumferential surface of rotating drum 50. Then, strand array 16 is removed from the pins and
30 held by the restraining belts atop advancing sheet 12 on the drum surface. Optionally, a cover sheet 14 fed from supply roll 15 may be applied atop the just-formed strand array/sheet assembly. By setting the traverse speed and the pin spacing on each pin conveyor, and then adjusting the relative speeds of the pin conveyors and the sheet-advancing support, the number of
35 transverse strands per unit length of composite sheet material produced can be varied as desired. As the assembled sheet substrate 12, strand array 16 and optional cover sheet 14 are advanced, the adhesive becomes set and

composite sheet material 18 is completed. Then, the composite sheet can be wound up or forwarded to further processing operations.

When the strand employed in the process or apparatus of the invention is an elastic strand (e.g., spandex), the resultant composite sheet material 18 can be cut in an optional subsequent step substantially parallel to the direction of the transverse strands to form elastic tapes or swatches. Then, the elastic tapes or swatches can be attached as elastic waistbands, side panels, closure tapes, frontal tapes, back panels and leg bands to disposable diapers and adult incontinence articles. High speed equipment of the kind disclosed by Merkatoris et al, U.S. Patent 5,296,080, is suitable for the attachment of the elastic components. Composite sheet material 18 formed by the process of the invention with strand that is not elastic is useful as strand-reinforced fabric, film, laminate, and the like. In such uses, strand 10 preferably is made of high tenacity fibers or filaments of polymers such as nylon, aramid, polyolefin, or polyester, or of glass or the like.

As used herein the term "strand" includes any monofilament, multifilament or staple yarn or thread. The strand can be of any decitex suitable for the application for which the resulting composite sheet material is intended. The strand can be made of synthetic or natural fibers. For elastic composites, the strand can be of natural or synthetic materials such as rubber, spandex or other elastomeric material. The term "spandex" has its usual generic meaning; namely, fiber made from a long chain synthetic polymer that comprises at least 85% by weight segmented polyurethane. Preferably, the spandex is employed with no lubricating finish on its surface so that better adhesion can be obtained between the spandex and the sheets.

Sheets suitable for use in the invention as advancing sheet substrate 12 include film, woven fabric, knit fabric or nonwoven fabric. The fabrics can be of natural or synthetic fibers such as cotton, wool, polyester, nylon, polypropylene, polyethylene, or the like. The films can be of polyethylene, polyester, polyfluorocarbons, polyimide, polypropylene, or the like.

Composite sheet materials 18 made by use of the process and apparatus of the invention typically have desirable resistances to impact, puncture and tear. Properties of the composite sheet can be further enhanced by processing the composite sheet material through the apparatus again one or more times. Uses for composite sheet material produced by the invention include tarpaulins, cargo curtains, bags, inflatable structures,

hospital gowns, disposable coveralls, and the like. In some uses, elastomeric and reinforcing strands can be used advantageously together.

Various embodiments of the apparatus of the invention will now be described in further detail.

5 Cam/traverse-guide housing 30 encloses rotatable cylindrical cam 32. Housing 30 also supports upper and lower guide rails 34, 35, between which strand traverse guide 36 is mounted. Housing 30 also prevents lubricating oil used on the cam from spraying into the work area. A 30-weight oil is suitable for lubricating the cam. Figure 8 is a front view
10 of housing 30, with a portion cut away to show cylindrical cam 32 within. Cylindrical cam 32 has groove 33 cut into its surface. The cylindrical cam is rotated by means not shown through cam shaft 31. As shown by Figs. 11a, 11b and 12, strand traverse guide 36 comprises a tip 37 for holding the strand and a base 38 which acts as a cam-follower. The base or cam-
15 follower portion 38 of strand traverse guide 36 is seated in cam groove 33 and slides through the groove path as cylindrical cam 32 is rotated. Rotation of grooved cylindrical cam 32 causes strand traverse guide 36 to slide to and fro between the straight edges of upper and lower guide rails 34 and 35. Figure 9 is a front view detail of the cylindrical cam 32 with groove
20 33 in which the strand traverse guide cam follower 38 is to be seated. An access notch, not shown, can be provided in one of the guide rails for convenient installation of the strand guide in the cam groove and between the guide rails. A lead-in channel, not shown, connected to the groove in the circumferential surface of the cam, in a position that can be aligned with
25 the access notch in the guide rail, permits convenient seating and removal of the strand guide.

 Figures 10a, 10b and 10c show three developed surfaces or "profiles" of cams for use in the apparatus of the invention. Each profile represents the complete surface of a cylindrical cam laid out in a plane. The
30 curve represents groove 33 of cylindrical cam 32. In operation, the cam follower of the strand traverse guide follows the groove path. The profile represents one rotation of the cam and results in one to and fro traverse of the strand traverse guide. Alternatively, suitable cams can have more than one rotation of the cam resulting in one to-and-fro traverse of the strand
35 traverse guide. In following the groove of the cam profile shown in Figure 10a, the strand guide reverses direction immediately upon reaching the extreme end of its traverse. This cam is very similar to the cam disclosed in Akers et al, U.S. Patent 3,675,863. The flattened portions of the profile of

Fig. 10b generate some "dwell time" at the extreme ends of the traverse by flattening of the profile. The dwell time increases the clearance of the strand guide around the pins of the pin-conveyor wheels and allows higher process speeds to be attained. Accordingly the profile of Fig. 10b is preferred over the profile of Fig. 10 a, which provides no dwell time at the point of traverse reversal. A further improvement in cam profile is shown in Figure 10c, in which a small angle, α , of less than 1 degree, is created between the flattened dwell portion of the profile and the edge of the cam. This maintains a small side pressure on the yarn guide so that it smoothly enters the turn at the end of the dwell section, thereby reducing wear on the guide and permitting higher speeds.

Figs. 11a, 11b and 12 show in greater detail cam follower 38 and tip 37 of strand traverse guide 36. The cam follower is seated to slide within groove 33 of cylindrical cam 32 causing guide 36 to slide to and fro between guide rails 34 and 35. In operation, as shown in Figs. 1-6, as cylindrical cam 32 is rotated, strand traverse guide 36 moves strand 10 to and fro to loop the strand about pins 42, 42' of pin-carrying conveyors 40, 40'. Pins 42, 42' are driven in a semicircular path that sweeps through the path of the strand traverse guide (after the guide has passed) to engage the strand 10. Figs. 6 and 11a depict guide rails 34, 35 as flat. Fig. 11b depicts an upper guide rail 34, preferred for bottom-fed strand, having a shallow depression or groove in its surface at the region of closest approach of the pins 42, 42' to rail 34. This permits the pins to sweep more deeply through the strand traverse path without hitting the guide rail. Also, as shown in Figs. 11a and 11b, for bottom fed strand, upper rail 34 is recessed by an angle θ , usually of less than 10 degrees, to further assure a close, unimpeded approach of the pins to the strand traverse path. The close approach of the pins to the face of the guide rails assures that as the pins contact the strand, the strand is secure in the notch of the traverse guide tip. Details of the notched tip of the strand guide are depicted in Figs. 12 and 13. Such notched guide tips are disclosed by Altice et al, U.S. Patent 3,086,722. If the strand is fed from above the apparatus, the central axis of the semicircular path of the pins preferably is positioned slightly below the path of strand traverse guide, and the hollows or grooved areas are on the lower guide rail to accommodate the path of the pins.

In a system tested by the inventors, tip 37 of the guide 36 extended about 0.098 inch (2.5 mm) above the base of the strand guide and had a notch about 0.060-inch (1.5-mm) deep. Of course, guides of other

dimensions can be used satisfactorily. Figure 13 illustrates a key-hole shaped notch for the tip of the strand traverse guide. The key-hole notched tip is preferred for better retention of the strand in the guide. To minimize wear and friction, tip 37 preferably is constructed of a ceramic material having a surface roughness no greater than 32 micro inches RMS. When a plastic guide is employed, the ceramic tip can be integrally molded with the plastic to form the completed guide. For smoothest operation, the weight of the traverse guide weight is minimized. A typical plastic traverse guide with ceramic tip can weigh as little 5 to 10 grams.

As shown in Figs. 1-5, strand 10, carried by reciprocating strand traverse guide 36, is looped around pins 42, 42' of a pair of pin-carrying conveyors 40, 40' to form a strand array. As illustrated in Figs 1-5, the pin-carrying conveyors are wheels, each having a plurality of pins projecting from its surface. A pin-carrying conveyor wheel is located near each end of the guide traverse path. The pin-conveyor wheels are spaced apart a distance that is somewhat less than the full stroke of the traverse guide. As referred to herein, the stroke of the traverse guide is equal to one-half the length of the full to-and-fro traverse of the strand traverse guide. Figs. 14a and 14b respectively depict a typical pin-conveyor wheel 40 with a plurality of pins 42 projecting outwardly from the wheel. The wheel has an central annular cylindrical hub 41 for mounting a drive shaft (not shown). The pins can be press-fit, brazed, welded, or bonded into spaced holes in the wheels. Typically, they are rotated at a rate in the range of 100 to 600 revolutions per minute; at least 200 rpm is preferred.

In another embodiment of the pin wheels, to ease strand removal from the pins, the pins can be made retractable, as for example by a cam and spring mechanism. As illustrated in Figures 1 and 5 for bottom-fed strand, the axes of the pin-conveyor wheels are preferably positioned slightly above (for example, by about 2.5 mm) the elevation of the strand traverse guide path to allow deeper penetration of the pins across the path of the strand guide. As illustrated in Fig. 4 for top fed strand, the axes of the pin-conveyor wheels are positioned slightly below the elevation of the strand traverse guide. Pin-conveyor wheels 40, 40' are driven by conventional means not shown in synchronization with the traverse guide. The pin-conveyor wheels are spaced from each other by a distance that is shorter than the traverse guide stroke but sufficiently long to permit restraining belts 52, 52' to capture the ends of the strands. The angular location of pins on the circumference of one wheel is off-set from the

angular position of the pins on the circumference of the other wheel by one-half of the pin spacing. For high speed looping of strand around the pin of the pin conveyors, a minimum clearance 0.040 (1 mm) between the strand traverse guide and the pins of the pin-conveyor wheels has been found to be
5 satisfactory.

The detail drawings of Figs. 15a and 15b, show a pin 42 canted at an angle β from the plane of wheel 40 and projecting from the surface of the pin-conveyor wheel. A typical pin can project 0.25 inch (6.4 mm) from the surface. The pin is directed slightly away from the center of the strand
10 traverse path to improve the ability of the pin to hold the strand securely in place on the wheel. Angle β can be as large as 45 degrees, but usually is smaller. As illustrated in Fig. 15b, the pin has a shoulder about 2/3 of the distance from the point at which the pin is secured to the wheel to the exposed end of the pin. A shoulder located between 0.4 and 0.8 of said
15 distance usually ensures satisfactory looping of the strand.

In Figs. 16a and 16b respectively, the pin-conveyor wheels 40, 40' are schematically shown to be canted toward or away from each other. Such arrangements are particularly useful with elastomeric strand. As shown in Figure 16a, strand 10 is formed into a looped strand array on the
20 pin-conveyor wheels, and the canted wheels allow the strand to retract before the strand is laid down on the sheet substrate carried by sheet support drum 50. In Figure 16b, strand 10 is formed into a looped array on the pins of the pin-conveyor wheels and then stretched by the canted wheels before being laid down on the moving sheet. With this latter configuration, a
25 shorter traverse stroke and therefore, higher speeds can be used. While on the pins, a spandex strand typically can have an elongation that is in the range of 10 to 400% beyond its relaxed length.

As illustrated in Figs. 1-5, sheet 12, which is to become the substrate of the composite sheet material 18 to be produced by the
30 invention, is advanced on the surface of sheet support drum 50. Drum 50 is positioned so that at least a part of its circumferential surface is between pin-conveyor wheels 40, 40'. Other sheet support surfaces contemplated for use in supporting the sheet in its passage between the pin-conveyor wheels, include for example, an endless flat belt or screen. An endless belt is
35 advantageous when additional time is required for maintaining the strand array and sheet assembly restrained while the adhesive is set. To keep laid-down strand array 16 in position atop advancing sheet substrate 12, a pair of restraining belts 52, 52' are employed. Restraining belt 52 is driven by

contact with the moving sheet support drum around a set of four idler rolls 54, 55, 56 and 57; belt 52' is driven in the same way around corresponding idler rolls 54', 55', 56' and 57'. Idler rolls 54, 54' are positioned so that strand array 16 is initially captured at the nip between the belts going
5 around rolls 54, 54' and rotating sheet support drum 50 before the strand looped around pins 42, 42' of pin-conveyor wheels 40, 40' is removed from the pins. Drum 50 can have circumferential grooves aligned with the restraining belts to aid the belts in holding the advancing strand array and sheet in position on the drum. Idler rolls 54, 54' preferably are of small
10 diameter so that the distance between the point at which the strand is contacted by the restraining belts and the point at which the strand is fully captured in the nip between the belts and the drum is as small as practicable. Preferably located immediately upstream of the nips between the restraining belts and the drum, is adhesive applicator 20, which applies adhesive to the
15 strand and/or advancing sheet. A wide variety of adhesives are suited for use in the apparatus, though hot melt spray adhesives are preferred. The width of sheet affected by the adhesive applied to the strand and/or sheet is designated "W" in Fig. 2 and is a little shorter than the distance between the restraining belts.

20 Restraining belts 52, 52' are preferably V-belts and more preferably grooved V-belts. Such belts hold the strand and sheet on the sheet support drum more securely than do belts of round or flat cross-section. The belts are made of flexible materials to permit proper passage of the belt around the smallest diameter idler rolls (i.e., 54, 54').

25 Restraining belts 52, 52' operate at the same linear speed as the circumferential speed of sheet support drum 50. Immediately downstream of the just-described belt/drum nips, cutters 60, 60' are positioned on each side of drum 50 (as best illustrated in Fig. 2 and 7). Various types of cutters can be used, such sharp edges, hot wire cutters (i.e., electrically heated
30 resistance elements), or any other means suitable for the particular kind of strand being cut. Instead of employing cutters, stripping fingers may be positioned so as to lift the loops of strand off the pins after the strand is engaged by the restraining belts. Using stripping fingers leaves loops at the selvage of the final composite sheet product. Optionally, a press roll 58
35 can be used to press a cover sheet 14, supplied from roll 15, atop restrained assembly of strand array 16 and sheet substrate 12, while the assembly is still on the support drum and before the applied adhesive has set. A takeoff roll 65 can be used to guide the completed composite sheet material away

from the drum and to a suitable collection means or to further processing steps. The assembly of strand, sheets and adhesive are restrained on the drum for a sufficient time (or distance on the drum) to permit the adhesive applied to the strand and sheet to set.

5 Figs. 17a-e show various patterns of strand array 16 on substrate sheet 12 that can be made with the present invention. The array of Fig. 17a is prepared with the apparatus herein before described with regard to Figs. 1 and 2. Fig. 17b is a similar pattern but the ends of the strand 10 extend beyond the edges of the sheet 12. This pattern also can be made if
10 the distance between the pin-conveyor wheels is shorter than the axial length of the sheet support drum and the width of the substrate sheet. Figs. 17c and 17d show patterns comparable to 17a and 17b, but with two strands 10 having been laid down on a sheet 12. To make these latter patterns, one pair of a pin-conveyor wheels is used in conjunction with two cam-driven
15 strand traverse guides to loop the strands onto the pins of the pin-conveyor wheels. The pattern of Figure 17e is made when one employs non-round (i.e., oblong) pins which rotate after having had strand looped around them. The narrow profile of the pins is presented during the strand looping. Rotation of the pins after the strand looping "expands" the machine-
20 direction length of the strand and results in a strand array in which the strand segments traversing the final composite sheet material are more parallel to each than when stationary pins of round cross-section are used.

EXAMPLE

25 This example describes a test that demonstrates the suitability of the process and apparatus of the invention for making elastic composite material at high speed and installing the material as elastic component in a garment, in particular an elastic waistband in disposable diapers. The apparatus for making the elastic composite sheet material used for the waistbands is substantially as illustrated in Fig. 1. The process also can be
30 carried out using other embodiments of the invention.

 The starting materials are as follows. A 620-dtex LYCRA® XA™ spandex (sold by E. I. du Pont de Nemours & Co., Wilmington, DE) is used as elastic strand 10. A 23.3-g/m² Type 6700 thermally bonded polypropylene nonwoven fabric (sold by Fiberweb Group Inc.,
35 Simpsonville, NC) is used as substrate sheet 12. A 0.001-inch (0.025-mm) thick polyethylene film (sold by Consolidated Thermoplastics Co., Dallas, TX) is used as cover sheet 14. Findley 2276 hot melt adhesive (sold by Findley Adhesives, Inc., Wauwatosa, WI) is sprayed onto the strand and

substrate sheet to obtain a total adhesive loading of 12 mg/in² in the final composite sheet material.

The strand is fed under tension to reciprocating strand guide which is driven by a cylindrical cam rotating at 2,000 rpm (rotations per minute). The strand is supplied at an extension of about 300% beyond its relaxed length. The strand traverse guide has a 9.5-inch (23.5-cm) stroke and makes 2,000 to-and-fro cycles per minute. A pair of parallel pin-conveyor wheels, 8.75-inches (22.2-cm) apart (i.e., the minimum distance between the imaginary circles formed by the centers of the bases of the pins on each wheel) and each of 6.37-inch (16.2-cm) diameter are rotated at 200 rpm. Each pin-conveyor wheel has ten pins equally spaced apart by a circumferential distance of 2.0-inches (5-cm). The pins are canted outward by 20 degrees from the wheel circumferential surface. The cam profile is as given in Figure 10b. The positions of the pin wheels and strand traverse guide are set to provide a clearance of at least 0.04 inch (1 mm) between the pins and the strand traverse guide near the end of each traverse stroke. The axes of the pin-conveyor wheels are located 0.15 inches (3.8 mm) above the elevation of the axis of the path of the traverse guide. Fig. 15b illustrates the configuration that is used for the pins and the pin-conveyor wheels. Each pin is of circular cross-section and has a shoulder of the design illustrated in Fig. 15b. The pins project above the wheel surface. The pin shoulder is located 0.07 inch (1.8 mm) from the exposed tip of the pin. The large diameter portion of the pin is 0.060 inch (1.5 mm) and the small diameter portion (i.e., the portion closest to the exposed tip of the pin) is 0.038 inch (1 mm). The sheet support drum has a 9.5-inch (23.5-cm) diameter and is rotated at 25 rpm. The resultant composite sheet material is removed from the drum at a linear velocity of about 19 meters per minute.

The composite sheet material is then fed to a commercial Nuova Red diaper-making machine having a belt-type waistband applicator. The elastic composite sheet material is fed, cut, vacuum-transferred and glued into the disposable diapers to form satisfactory waistbands in the diapers at a rate of about 300 diapers per minute.

The preceding example illustrated the use of elastic composite sheet material of the invention in waistbands of disposable diapers. The elastic composite sheet is also suited for installation in adult incontinence articles as waistbands, and in diapers and adult incontinence articles as stretch side panels, closure tapes, frontal tapes, back panels, leg bands, and the like. The elastic composite sheet material is also suited for installation

in portions of other types of garments, such as in wrist bands of sweaters, waist bands of trousers, elastic portions of athletic sportswear, as well as many other articles of clothing.

We claim:

1. In a process for making a composite sheet material, wherein the process comprises
advancing in a longitudinal direction a sheet substrate, a first
5 conveyor and second conveyor, the sheet substrate having two lateral edges and an upper and a lower surface and each conveyor having a plurality of spaced apart pins extending therefrom in a direction generally perpendicular to the movement of the conveyors, the conveyors being spaced apart and operating in synchronization,
10 supplying a strand to a device that reciprocates the strand to and fro across a traverse path, the traverse path being generally transverse to the longitudinal direction of the advancing sheet substrate,
advancing the conveyors to move the pins through a path that intersects the traverse path of the strand, thereby causing the strand to
15 repetitively loop alternately, at each end of the traverse path, around a pin on the first conveyor and then around a pin on the second conveyor to form a strand array having edges carried by the pins,
applying an adhesive to the strand array or to the advancing sheet substrate or to both the strand array and the advancing sheet substrate,
20 transferring the strand array from the pins to the upper surface of the advancing sheet substrate to form a strand-sheet assembly,
optionally adhering a cover sheet atop the strand-sheet assembly and
forwarding the resultant composite sheet material to a windup
25 or to further processing steps,
the improvement comprising:
feeding the strand to a strand traverse guide driven by a rotating cylindrical cam,
moving the pins through an arcuate path that intersects the
30 traverse path of the strand,
advancing the sheet substrate on a moving sheet support, and
restraining each edge of the strand array in position on the sheet substrate from a location after the point where the strand array is transferred from the pins to the advancing sheet substrate to a location beyond the point
35 where the applied adhesive has become set.
2. A process in accordance with claim 1 wherein the strand is reciprocated at a rate in the range of 250 to 3,000 to-and-fro cycles per minute with a traverse stroke of at least 5-centimeter length, the pin-

carrying conveyors are moved at an equal speed and are rotated at a rate of 100 to 600 revolutions per minute through a semicircular path that intersects the traverse path of the strand..

3. A process in accordance with claim 2 wherein the strand is
5 an elastic strand that is elongated in the range of 10 to 400% beyond its original relaxed length while being supplied to the strand traverse guide and/or while being restrained in the strand array.

4. A process in accordance with claim 1, 2 or 3 wherein the sheet substrate and the optional cover sheet are each a nonwoven fabric.

10 5. A process in accordance with claim 1, 2 or 3 wherein the sheet substrate is a nonwoven fabric and the optional cover sheet is a film.

6. A process in accordance with claim 1, 2 or 3 wherein the strand is a spandex and the resultant composite sheet material is cut into lengths and attached as elastic components of a garment.

15 7. A process in accordance with claim 6 wherein the composite sheet material is cut into tapes or swatches and supplied to an elastic swatch applicator of a diaper-making machine to adhere the cut tapes or swatches to the diapers to form elastic bands in the diapers.

20 8. A garment having installed therein an elastic component made by the process of claim 6.

9. A garment of claim 8 wherein the elastic component comprises a waistband, side panel, closure tape, frontal tape, back panel or leg band.

25 10. A garment of claim 9 wherein the garment is a disposable diaper or an adult incontinence article.

30 11. An improved apparatus for making a composite sheet material in which a strand supplied through a reciprocating guide is looped around pins of a pair of spaced-apart pin conveyors, the pin conveyors transfer the strand transversely to a sheet substrate advancing in a longitudinal direction and the strand is adhered to the sheet substrate, wherein the improvement comprises:

35 the reciprocating guide is a lightweight strand guide connected to a cylindrical cam, the strand guide having a slotted tip for receiving the strand and a follower portion for fitting a groove in the cylindrical cam, so that when the cam is rotated the strand guide is driven to and fro along a traverse path having a first end and a second end;

the pin conveyors each have a plurality of evenly spaced-apart pins projecting from the surface of the conveyor, the first conveyor being

positioned near the first end of the traverse path and the second conveyor being positioned near the second end of the traverse path, and the space between the conveyors being less than the distance between the first and second ends of the traverse path;

- 5 means for moving the pins of the conveyor through an arcuate path that intersects the traverse path, so that during operation strand carried by the reciprocating guide, near each end of each traverse, is looped around a pin of the pin conveyor;

- 10 a surface for supporting and moving the sheet substrate in the longitudinal direction into a position for transferring the strand from the pins to the sheet substrate, the transfer position being located between the pin conveyors and at a nip formed by a restraining means and the support surface;

- 15 means for synchronizing the relative speeds of the reciprocating traverse guide and the pin conveyors to assure the looping of strand on a pin of the conveyor at each end of the strand path; and

 means for controlling the movement of the restraining means and the support surface at equal speeds.

- 20 12. An improved apparatus of claim 11 wherein each pin conveyor is a rotatable wheel pin conveyor; the support surface is a rotatable cylindrical drum; and the restraining means is a pair of V-belts

- 25 13. An improved apparatus of claim 12 wherein the slot of the strand guide is a key-hole slot and each pin of each pin-conveyor wheel has a shoulder located between 0.4 and 0.8 of the distance from where the pin is secured to the wheel to the top of the pin and separating a larger diameter portion of the pin from a smaller diameter portion of the pin, the smaller diameter portion being the top portion of the pin.

14. An improved apparatus of claim 12 or 13 wherein the pin-conveyor wheels are canted toward each other or away from each other.

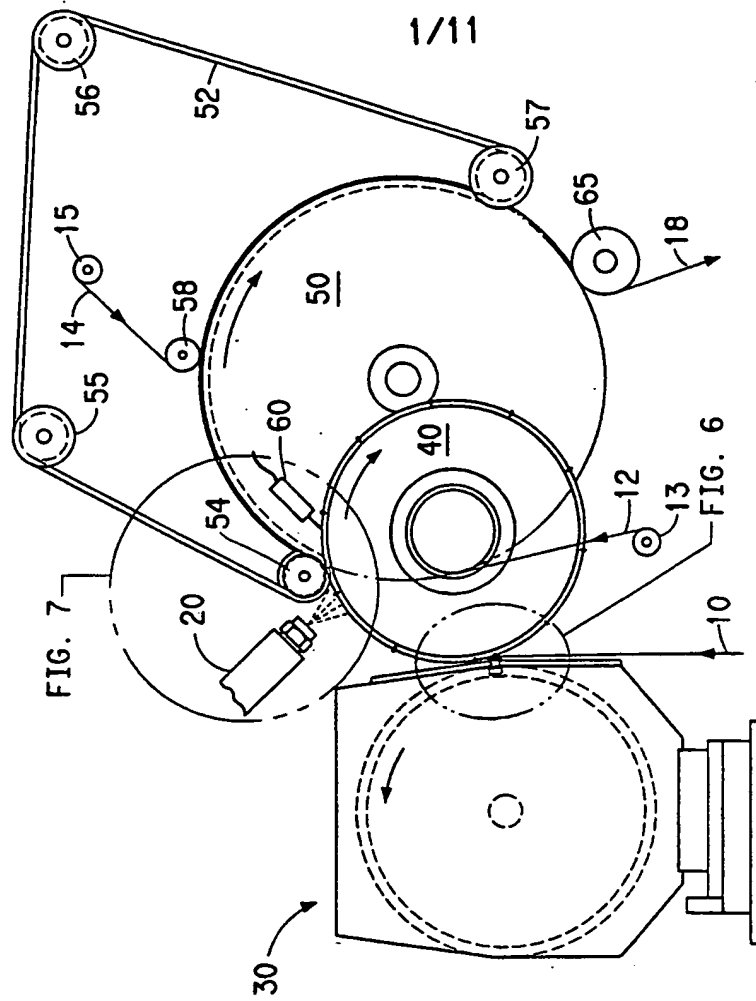


FIG. 1

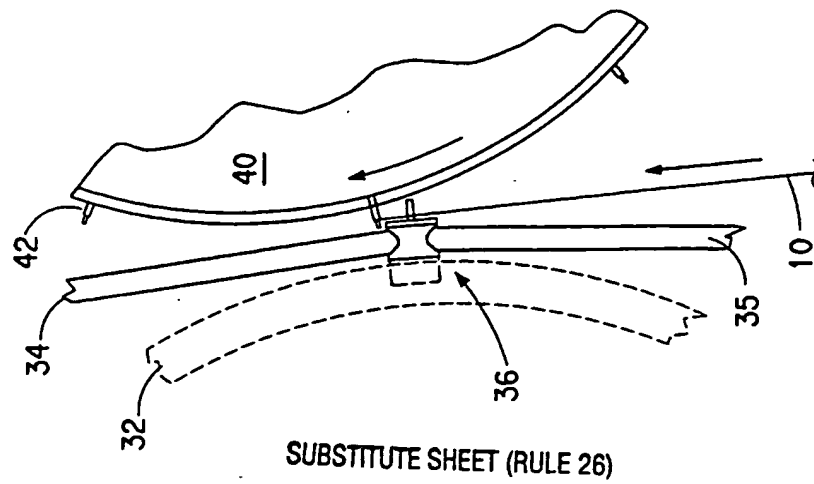
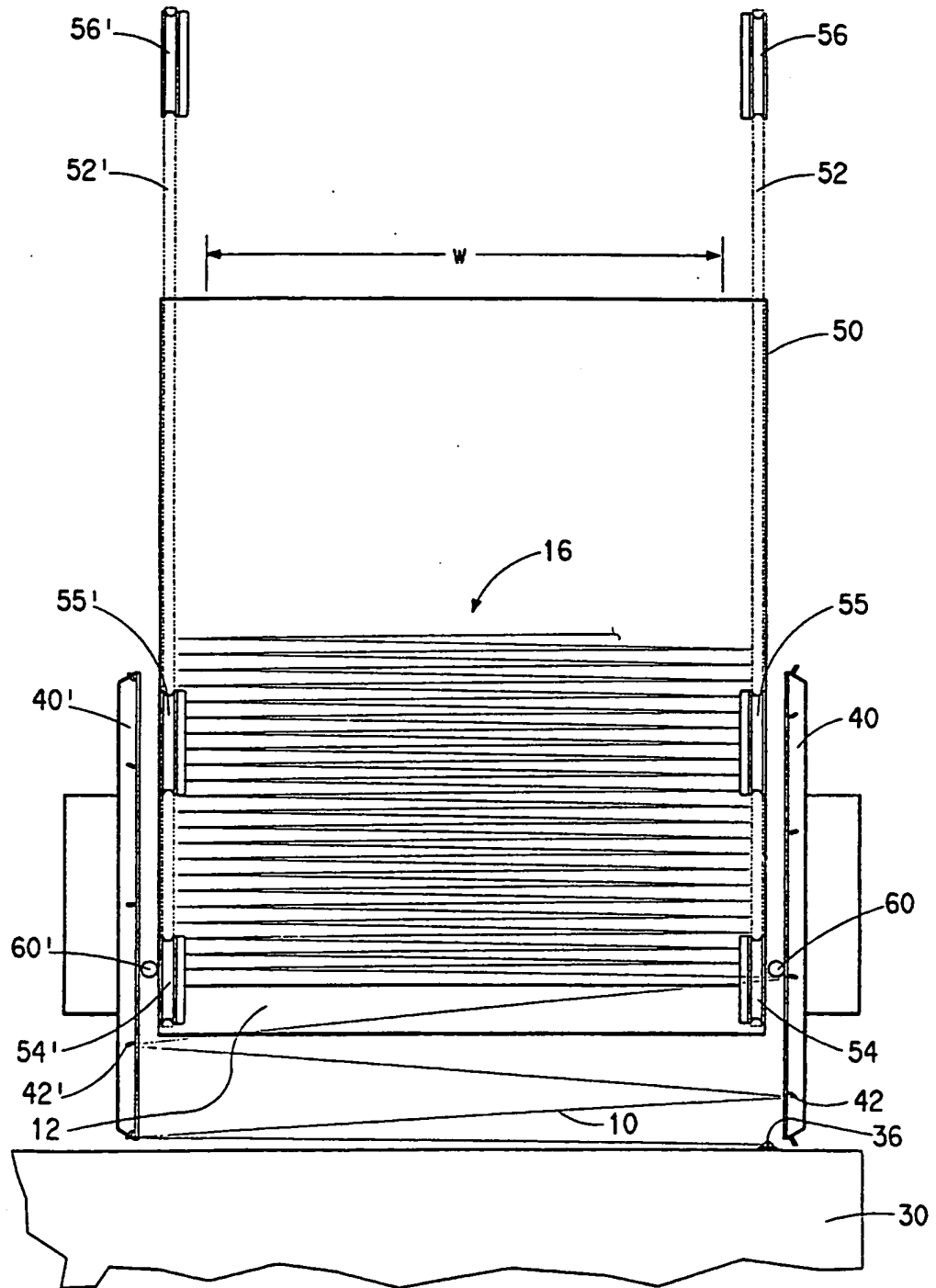


FIG. 6

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FIG.2



SUBSTITUTE SHEET (RULE 26)

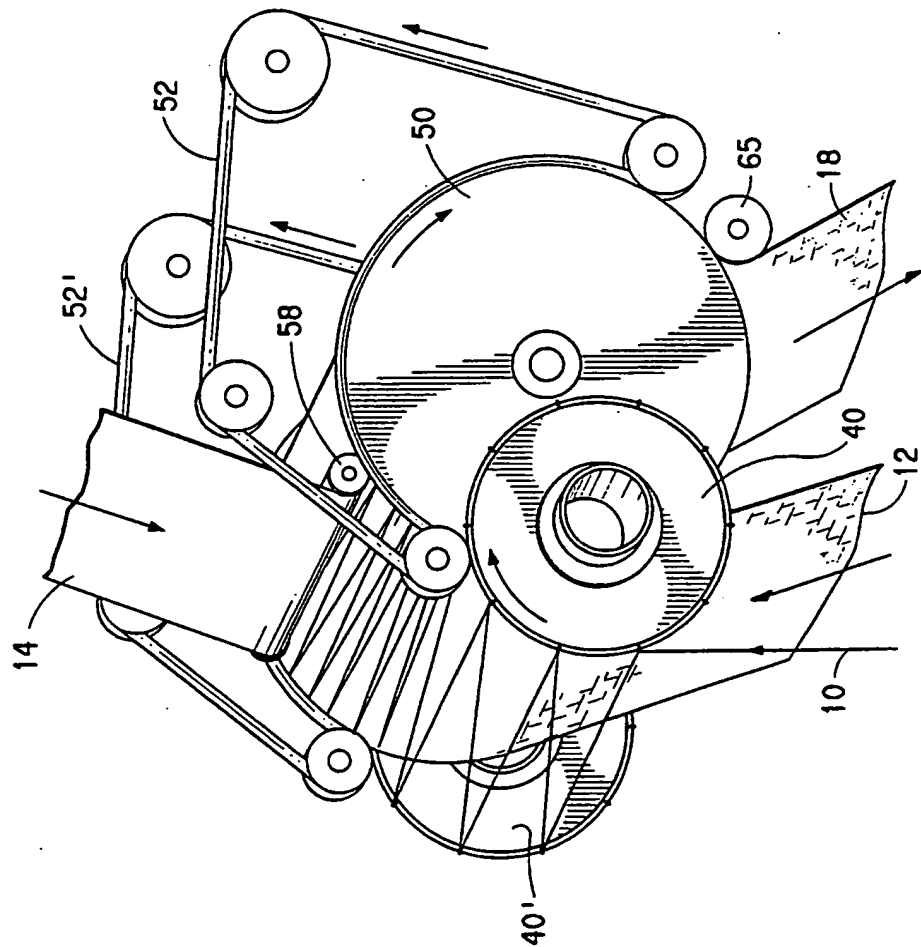


FIG. 3

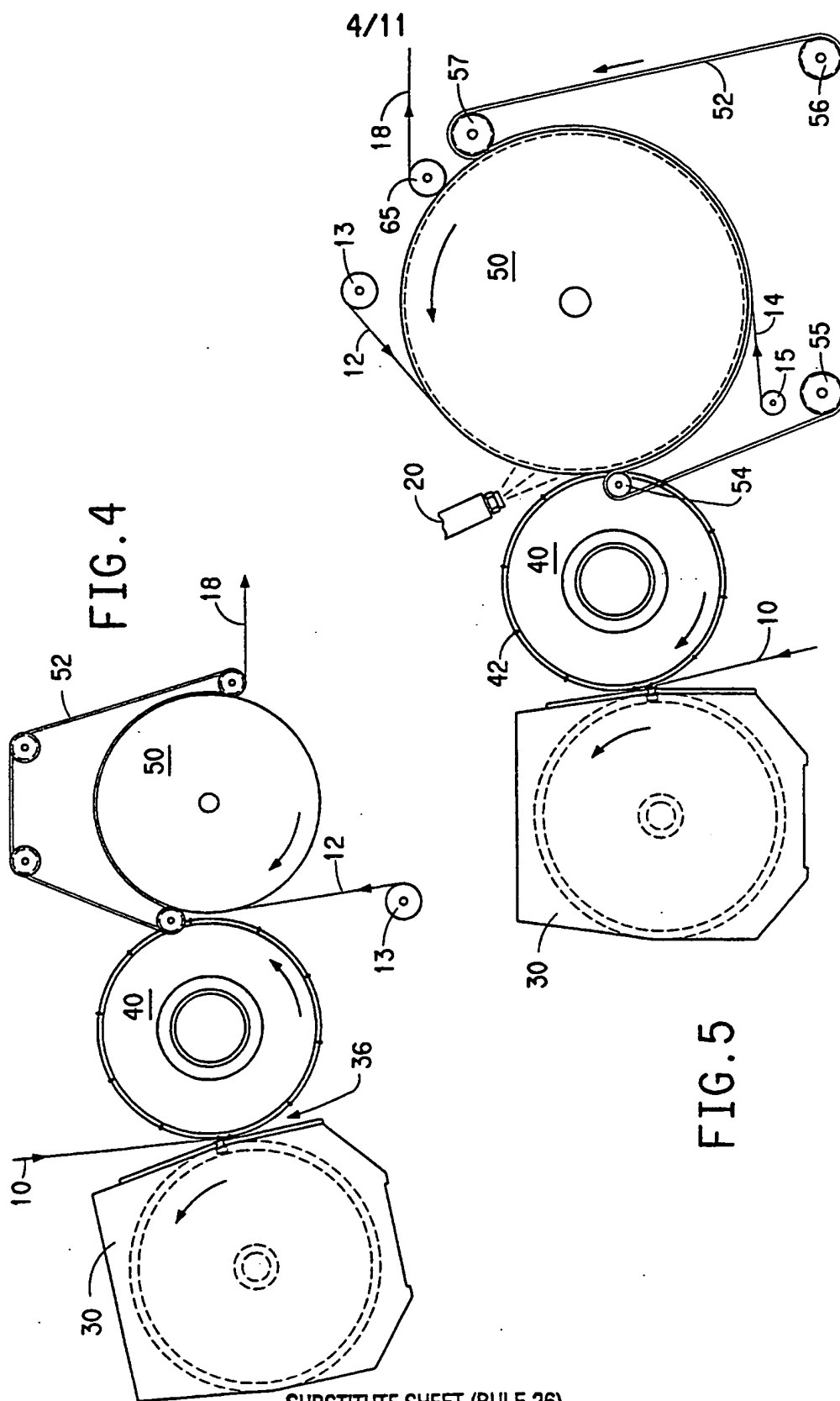
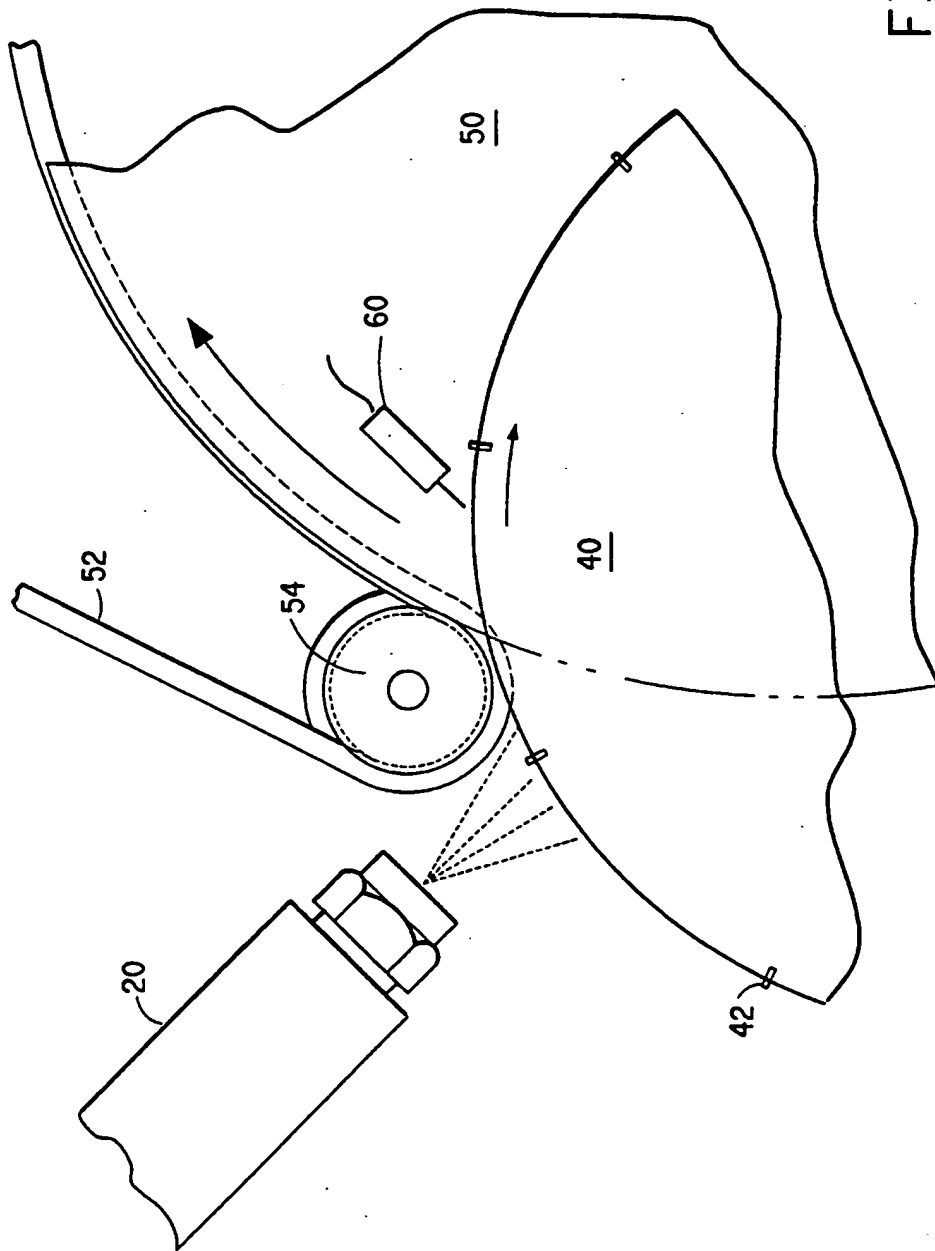


FIG. 7



SUBSTITUTE SHEET (RULE 26)

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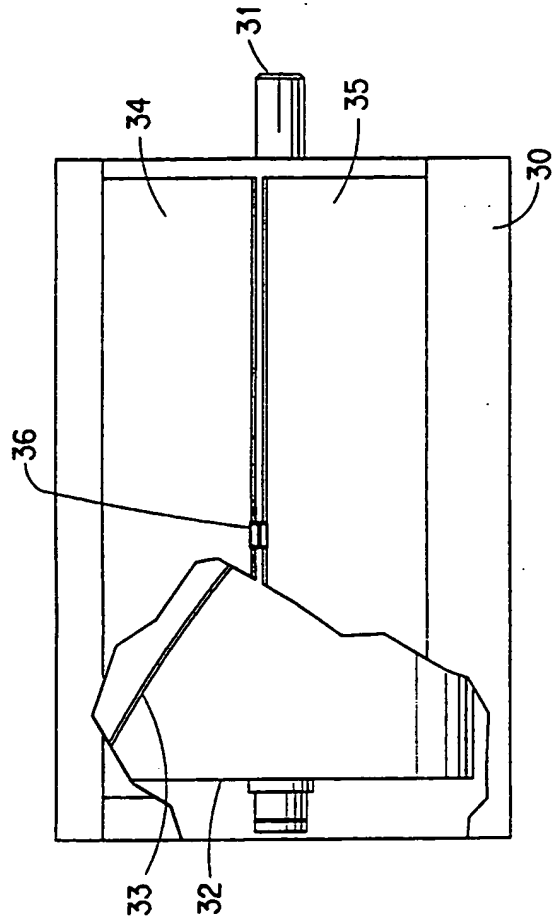


FIG. 8

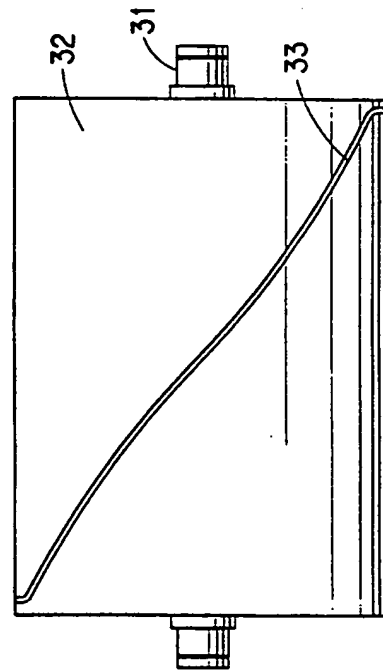


FIG. 9

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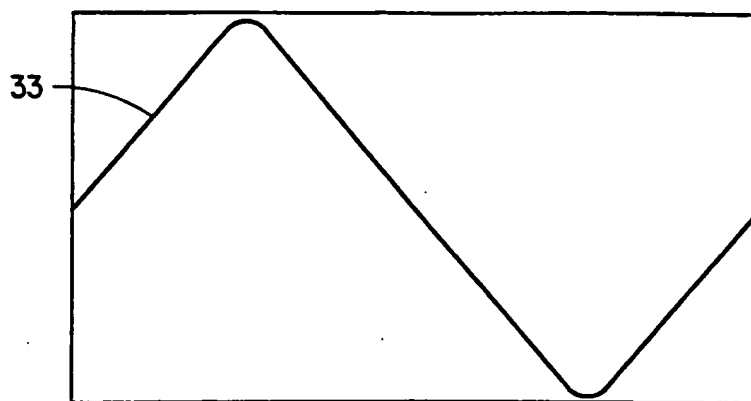


FIG. 10a

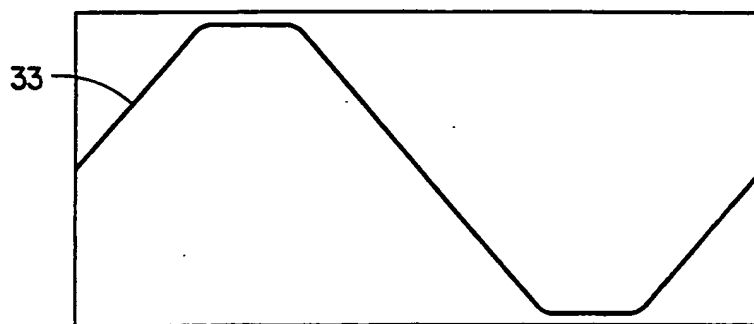


FIG. 10b

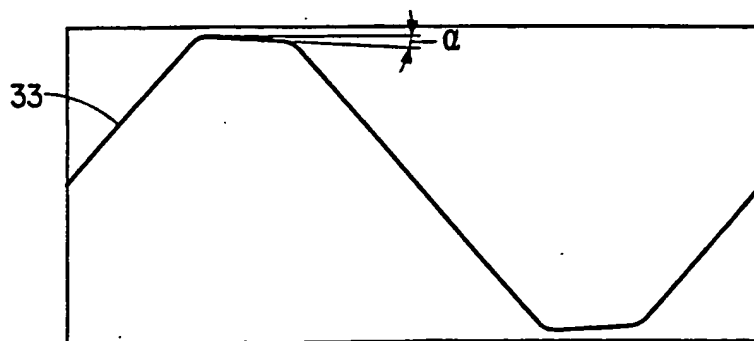


FIG. 10c

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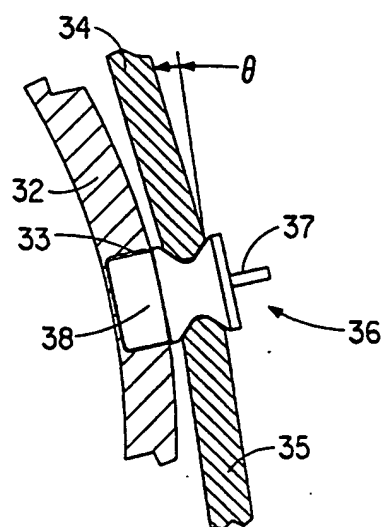


FIG. 11a

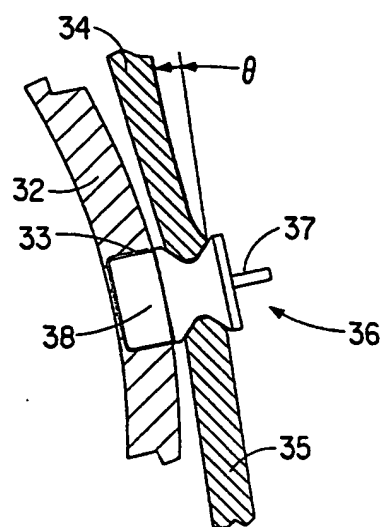


FIG. 11b

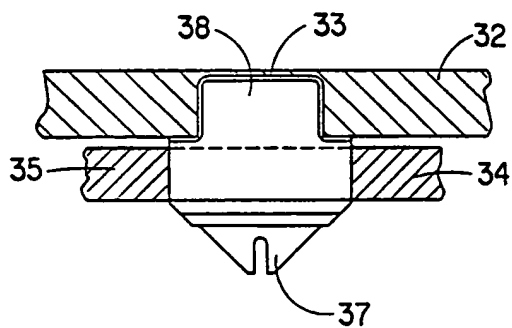


FIG. 12



FIG. 13

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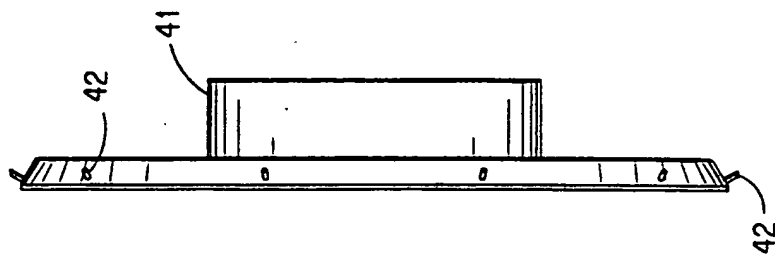


FIG. 14b

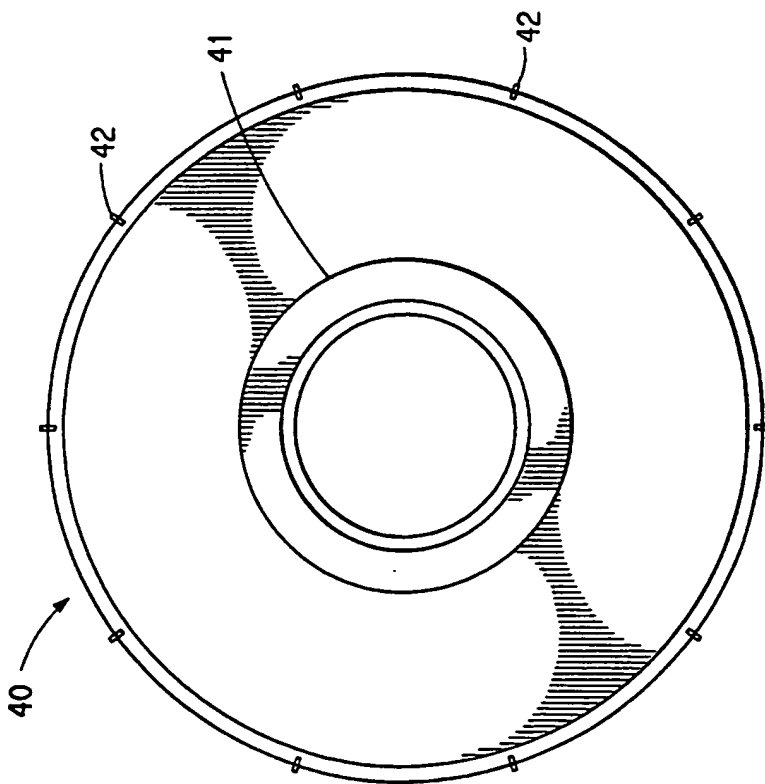


FIG. 14a

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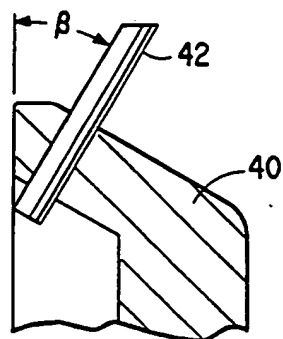


FIG. 15a

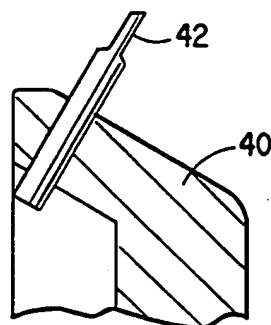


FIG. 15b

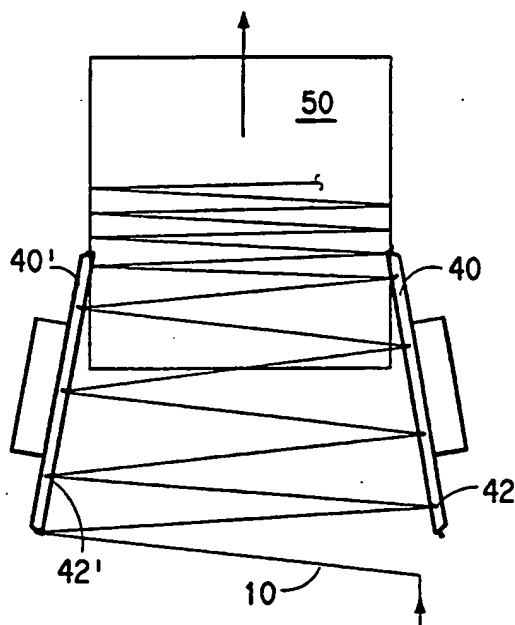


FIG. 16a

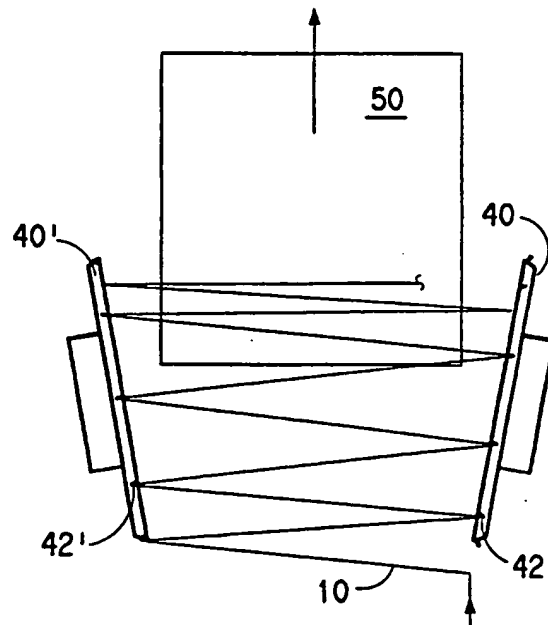


FIG. 16b

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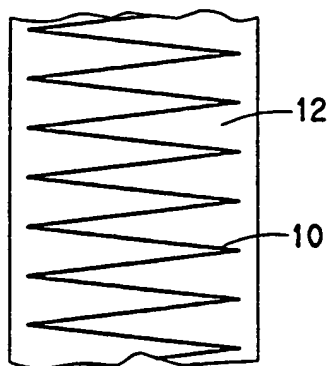


FIG. 17a

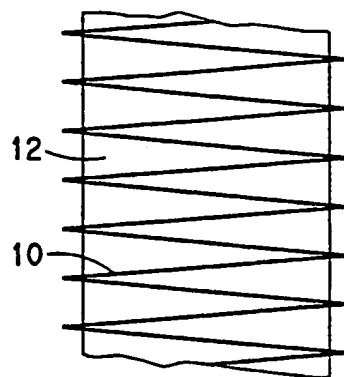


FIG. 17b

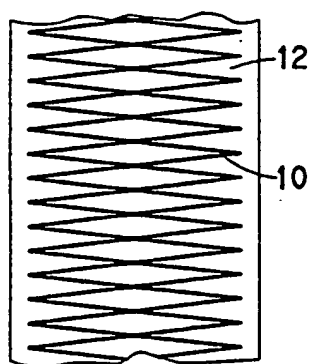


FIG. 17c

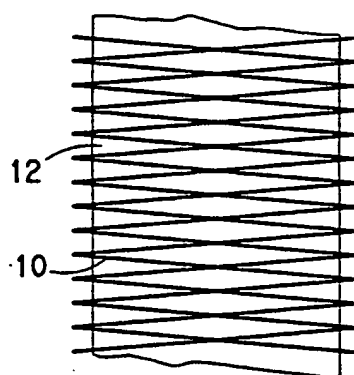


FIG. 17d

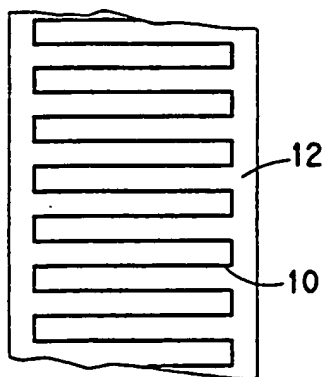


FIG. 17e

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/12646

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 D04H3/05

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 D04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,3 878 591 (JENSE WILLEM FREDERIK) 22 April 1975 see column 1, line 33 - column 2, line 42 ---	1,11
A	US,A,3 607 565 (EATON) 11 May 1971 see column 1, line 68 - column 7, line 58 ---	1,11
A	US,A,4 080 232 (FRIEDRICH) 21 March 1978 cited in the application see the whole document ---	1,11
A	US,A,2 962 080 (HIRSCH) 29 November 1960 cited in the application see column 1, line 23 - column 6, line 40 ---	1,11
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search

29 November 1996

Date of mailing of the international search report

19.12.96

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Authorized officer

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V Beurden-Hopkins, S

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/12646

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,2 812 797 (ESTEE ET. AL.) 12 November 1957 cited in the application see claims 1-12 ---	1,11
A	US,A,5 000 806 (MERKATORIS JOHN R ET AL) 19 March 1991 cited in the application see column 1, line 20 - column 6, line 15 -----	8-10

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/12646

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